THE COLLECTION AND ANALYSIS OF HUMAN FACTORS DATA IN TASK ANALYSIS

Rodney Paul Kempf

United States
Naval Postgraduate School

THESIS

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of
Human Factors Data in Task Analysis

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Rodney Paul Kempf
Captain, United States Marine Corps
B.A., The University of Texas, 1964

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ABSTRACT

This paper develops a questionnaire to be used in determining the necessity of various human factors to the successful performance of any particular job. Included in the proposed questionnaire are fifty-eight characteristics and a scheme for rating the variables.

Additionally, a program is developed for analyzing the data collected via the proposed questionnaire. The Friedman Two-Way Analysis of Variance by Ranks is used to detect significant difference between the characteristics, and, given a difference exists, a method similar to the Duncan Multiple Range Test is employed to separate the several characteristics into significance groups, the various groups being ranked on an ordinal scale.

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I. HUMAN FACTORS IN TASK ANALYSIS

Human endeavor may generally be separated into professions or occupations and further divided into specialties within the broader occupations. Furthermore, analysis of the specialties will reveal a variety of tasks contributing to successful job performance in the specialty. Each of these tasks, in turn, requires the exercise of certain physical and mental skills. Additionally, the worker may need to possess a certain psychological profile to perform his job adequately. These human variables, any of which may be common to many occupational specialties, may therefore be considered of basic importance to any task analysis, such task analysis being a study of a broad range of tasks with the purpose of consolidating any specialties enjoying a high degree of commonality in the skills, training, equipment and procedures required.

The modern profession of arms is like a microcosm of the whole of human endeavor. Even if one ignores the normal separation of the various services--such as the Army and the Navy--he must still recognize the existence of a wide variety of jobs within each service. Furthermore, some tasks are common to more than one service. For example, not only may a soldier operate a machine gun or drive a tank, and a sailor tend a boiler or man a ship's helm, but a soldier may be a tugboat crewman, a sailor a parachutist, or an airman a pipefitter.

The human variables, or human factors, contributing to job performance may be grossly divided into physical characteristics, mental abilities, psychological considerations and combinations of the preceding three categories. Examples of physical characteristics are strength, stamina and the use of the senses, while mental capabilities may include the use of the memory and learned skills. Tact and emotional stability are two of the factors falling into the psychological classification, whereas visual judgment such as the estimation of size or speed may be considered a combination of the physical and the mental. These broad divisions, however, do not adequately describe the skills or capacities necessary to perform a task, and a finer partition is desirable. The Canadian Armed Forces, in their analysis of the trades composing their job structure, listed 50 "Worker Characteristics" contributing to job performance. These included such variables as strength of the arms, keenness of vision and leadership. However, in defining the several worker characteristics, the Canadians pointed out that some of their variables could be expanded into additional characteristics. The Canadian worker characteristics and a short explanation of the Canadian rating system are included in this paper as Appendix A.

To supplement the task analysis of the United States Marine Corps, Professor G. K. Poock, a member of the Operations Analysis faculty at the Naval Postgraduate School, assisted by this investigator, developed an extension and modification of the Canadian list. A

discussion and presentation of the proposed questionnaire, together with proposals for the analysis of the gathered data, may be found in Reference 1.

This paper presents a study of the proposed data-gathering and analysis effort relating to human factors. Included is a further modification of the questionnaire originally proposed, a discussion of the development of a computer program for analyzing and grouping the worker characteristics, and the results of testing of the program, using simulated responses to the modified questionnaire.

II. DATA COLLECTION

The analysis of a job to determine what human variables a worker needs to perform the job requires that the investigator discover, first, any variable necessary and, second, to what extent that factor is needed. An investigator could, had he the time and funds, re-create a particular job in the laboratory. Of course, he would have to assure that all component tasks of that job were simulated. This could be a prodigious task for all but the simplest of occupations. If one adds to this the time consumed in repetition of the experiment to account for variability, the problem assumes formidable proportions. However, a feasible alternative exists in that one may travel to the field and observe, over a period of time, one or more of the men actually doing the job. The latter course seems superior in a number of areas.

Simulation entails simplification and a resulting loss of generality. No such loss accrues when the observations are of the actual job being performed. Furthermore, the workers themselves may be consulted on the necessity of any of the human factors involved, for it is unlikely that all tasks or job situations will occur during the course of the observations, and such information gathered from the workers would be of great value. Finally, the worker need not be removed from his job to participate in the experiment. The proposed questionnaire (Appendix B) was designed to be completed by either the observer or the worker, or preferably, by both.

A. THE VARIABLES

Were one to begin with no prior knowledge of human characteristics, the listing of such variables could prove quite difficult. However, it is safe to assume that all human traits and capacities have been catalogued. One such listing is the work of the Canadian Forces cited previously, and the author of this paper has considered that effort as essentially complete, although some revisions were effected.

Appendix A, while listing some fifty characteristics, suggests further possibilities. For example, in Item 10 of the list, defining "Foot-Hand-Eye Coordination," it is suggested that any coordination of the feet and the eyes not involving the hands should be entered as an additional characteristic. The author of this paper followed that suggestion and several others, incorporating them as separate characteristics. However, some of the suggestions appeared to be of a nature so remote from foreseeable human activity that they were not included in the proposed questionnaire. One such omission was leg-hand-eye coordination not involving the feet. A concrete example of such a dichotomy of the activity of the leg and the foot could not be visualized and was therefore not included.

One characteristic, Intelligence, defined as general problem-solving ability, was eliminated from the proposed questionnaire, inasmuch as the ability to solve problems is a conglomerate of several other listed factors such as decision-making ability and memory. Another factor, entitled "Work rapidly for long periods," was expanded

into six characteristics. Included in this expansion were working rapidly or performing heavy work for a series of short periods (analogous to the activity of a football player), a long period (analogous to the activity of a participant in a foot-race of substantial, but known length), or an indefinite period of time, perhaps the most important to the military because of the nature of combat.

Having isolated the human factors thought necessary, the characteristics were rearranged into a more orderly sequence. This was done primarily to allow the person completing the form to focus his attention to each of a group of related characteristics in its turn. Typical of such groupings are strength, stamina, or learned characteristics.

B. RATING THE VARIABLES

Having decided which human factors to treat, the author turned his attention to the problem of devising a rating system. Were an investigator to be equipped with some sort of ultimate electronic analyzer, he could simply attach a few electrodes and other impedimenta to the "typical" worker, and the machine would yield the degree of each characteristic necessary to the task being analyzed. Of course, even if the investigator were equipped with such a device, he would still be faced with the problem of choosing the "typical" worker. To be sure, there exist many devices to measure human factors, but a large number of them are quite bulky, of use only in a laboratory setting. Due to the static nature of such equipment, and other drawbacks, it was necessary

to attempt to obtain a sample of informed opinion--hence the questionnaire.

Remaining yet was the problem of choosing a rating scale. The scale ultimately chosen had to be discrete, a continuous scale not being warranted by the imprecise nature of the data to be obtained. A further problem to be solved was the choice of the number of points on the scale, each to represent a degree of necessity or level of that characteristic required. Between the extreme choices of only two points or a vast number of points lie many possibilities. However, a scale with many points approaches, in precision, the previously excluded continuous case. Therefore, this investigator limited consideration to scales with a "small" number of points. In that a certain amount of precision of definition was desired, a scale containing four points was chosen, the points defined thus:

(0) The characteristic is not required.

(1) The characteristic is occasionally required.

(2) The characteristic is frequently required, but not on a regular basis.

(3) The characteristic is regularly required OR, if not regularly required, of exceptional importance to the job.

The number of points chosen coincided with the number chosen by the Canadians. However, this investigator felt that the levels as defined above were more descriptive than the Canadian definitions, which were of the nature of "...low to medium degree...," "...above-average degree...," etc. It was for this reason also that a scale of

five or more points was not chosen. Although a case may be made for scales containing five, six or more points yielding a greater possibility of discernable statistical differences between the variables, this writer felt it was infeasible to assign concrete definitions to more than four levels. Thus, a scale of four points was chosen.

C. ADDITIONAL INFORMATION

It was also deemed necessary to collect some information of the subjects completing the questionnaire. Such information had to relate to the job performed and analyzed. Therefore, an indication of the subject's occupation was necessary.

The several occupational fields of the Marine Corps consist of Military Occupational Specialties (indicated hereafter as MOS), their number varying with the occupational field. For example, the infantry field has perhaps the simplest structure. Men of the rank of corporal and below are assigned, when qualified, military occupational specialties such as rifleman (0311) or mortarman (0341), while sergeants and above receive the MOS infantry unit leader (0369). The technical fields, such as electronics or aircraft maintenance, include a great many more specialties than the infantry, but even the relatively simple structure of the infantry reveals,for purposes of this study, the need for information in excess of MOS data because, while a corporal (0311) would probably lead a fire team and need some skills different from those of a corporal (0341) acting as a mortar gunner, the MOS 0369

could indicate either a sergeant leading a rifle squad or a gunnery sergeant acting as a battalion operations chief. Furthermore, while rank and MOS often indicate what job is being performed, but this is not always the case. For example, a corporal may act as a howitzer section chief, or a staff sergeant may perform as an acting company gunnery sergeant. Therefore, the actual job being performed by the subject should be obtained in a task analysis.

Further items of information which could prove useful to the analysis would be the time spent in the occupational field and the time spent on the present job. However, this information should be handled gingerly. While such information may give an indication of experience, it could also reveal, in the case of a low-ranking man with a great deal of time in the field, a lackadaisical performer whose rating would be of little worth.

Therefore, it was decided to include on the questionnaire not only the human factors to be rated, but also the following information:

1. Rank of the subject;
2. His assigned military occupational specialty;
3. His duty military occupational specialty (present job);
4. The experience he has in the occupational field; and
5. The experience he has in his present job.

The complete questionnaire is included in this paper as Appendix B.

III. ANALYSIS OF THE DATA

From the data gathered through the use of the proposed questionnaire, one would want, at the very least, to learn if there was any difference to be discerned between the human variables. However, this "bare-bones" information is of little use if one cannot determine where the differences lie. Therefore, a computer program was designed to test the data for significance, to rank the variables according to importance to the task being analyzed, and to group the variables in significance groups, i.e., groups of human factors the members of which do not statistically differ from one another, but each of which differ significantly from the members of all other groups. For example, if it were determined that no significant difference existed between any of the characteristics, all of them would be members of a single significance group, whereas, to look at the other extreme, if each possible pair of characteristics were to differ significantly, fifty-eight significance groups (assuming no additional characteristics were discovered) would be generated. Of course, in the first case, the program would not waste time generating a single group.

A. TESTING FOR STATISTICAL DIFFERENCE

Because of the nature of the data to be collected, no assumption was made about the distribution of the ratings, and a distribution-free test for statistical difference was indicated. The Friedman Two-Way

Analysis of Variance by Ranks, presented in Ref. 2 and Ref. 3, is such a non-parametric test and was employed by this investigator.

To use the Friedman test in the analysis of the collected data, the responses to the proposed questionnaire would be cast in the form below:

$$
\begin{array}{cccccccccc}
X_{11} & X_{12} & \cdot & \cdot & \cdot & X_{1j} & \cdot & \cdot & \cdot & X_{1k} \\
X_{21} & X_{22} & \cdot & \cdot & \cdot & X_{2j} & \cdot & \cdot & \cdot & X_{2k} \\
\cdot & \cdot & \cdot & & & \cdot & \cdot & & & \cdot \\
\cdot & \cdot & & \cdot & & \cdot & & \cdot & & \cdot \\
\cdot & \cdot & & & \cdot & \cdot & & & \cdot & \cdot \\
X_{i1} & X_{i2} & \cdot & \cdot & \cdot & X_{ij} & \cdot & \cdot & \cdot & X_{ik} \\
\cdot & \cdot & \cdot & & & \cdot & \cdot & & & \cdot \\
\cdot & \cdot & & \cdot & & \cdot & & \cdot & & \cdot \\
\cdot & \cdot & & & \cdot & \cdot & & & \cdot & \cdot \\
X_{N1} & X_{N2} & \cdot & \cdot & \cdot & X_{Nj} & \cdot & \cdot & \cdot & X_{Nk},
\end{array}
$$

where X_{ij} is the rating of the j-th characteristic by subject i, N is the total number of workers rating the several characteristics, k is the number of characteristics, and $X_{ij} = 0, 1, 2,$ or 3. The Friedman test, however, requires the use of data in the form of ranks, so the rating for each characteristic would be ranked from 1 to k for each of the subjects, the ranks in ascending order of the ratings. Since X_{ij} can have only one of four discrete values, 0, 1, 2, or 3, and there would be many variables to rate (58 in the case of the proposed questionnaire), ties are certain to be encountered. Therefore, ties would be assigned a rank equal to the average value of the tied ranks. For example, if

four of the characteristics were rated 0 by a particular subject, the ranks 1, 2, 3, 4 would be summed and the sum divided by the number of ratings tied, namely four, to yield an average value of 2.5. Then each of the four characteristics would be assigned this average rank. After the ranking has been accomplished, the format above would be recast to contain the ranks R_{ij} in place of the ratings X_{ij}. The data by ranks would then appear as below:

$$
\begin{array}{cccccccccc}
R_{11} & R_{12} & \cdot & \cdot & \cdot & R_{1j} & \cdot & \cdot & \cdot & R_{1k} \\
R_{21} & R_{22} & \cdot & \cdot & \cdot & R_{2j} & \cdot & \cdot & \cdot & R_{2k} \\
 & \cdot & \cdot & \cdot & & & \cdot & \cdot & & \cdot \\
 & \cdot & \cdot & & \cdot & & \cdot & & \cdot & \\
 & \cdot & \cdot & & & \cdot & \cdot & & \cdot & \\
R_{i1} & R_{i2} & \cdot & \cdot & \cdot & R_{ij} & \cdot & \cdot & \cdot & R_{ik} \\
 & \cdot & \cdot & \cdot & & & \cdot & \cdot & & \cdot \\
 & \cdot & \cdot & & \cdot & & \cdot & & \cdot & \\
 & \cdot & \cdot & & & \cdot & \cdot & & \cdot & \\
R_{N1} & R_{N2} & \cdot & \cdot & \cdot & R_{Nj} & \cdot & \cdot & \cdot & R_{Nk}.
\end{array}
$$

The Null Hypothesis H_0 for the Friedman test is that all the characteristics were drawn from the same population. Reference 2 shows that, if H_0 holds, the ranks in each column of the format above would represent a random sample from the discontinuous rectangular distribution of 1, 2, ... k (analogous to a uniform distribution in the continuous case) and the column sums would be approximately equal. On the other hand, if the Alternative Hypothesis H_1, that all the characteristics

were not drawn from the same population, holds, then the column sums could be expected to vary from column to column.

Friedman defines the test statistic as

$$\chi_r^2 = \left[\frac{12}{Nk(k+1)}\sum_{j=1}^{k}(R_j)^2\right] - 3N(k+1)$$

where N equals the number of rows (subjects), k equals the number of columns (characteristics), and $R_j = \sum_{i=1}^{N} R_{ij}$. Where N and k are "large" (both N and k in this study were considered sufficiently large), the Friedman statistic χ_r^2 is very closely approximated by the Chi-square statistic χ^2 with k - 1 degrees of freedom, and the critical value of χ_r^2 for a selected significance level α may be obtained from a Chi-square table. For the purposes of this study, α was chosen to be 0.05 and, with the use of Tables A and C of Ref. 4, the critical value of χ_r^2 was computed to be 75.352. Therefore it was concluded that if $\chi_r^2 \geq 75.352$ for any job under consideration, then a significant difference would exist between the human characteristics.

B. GROUPING AND RANKING THE HUMAN FACTORS

If the Friedman test were to reveal no statistical difference between the human characteristics, this investigator would accept this verdict and conclude that the several variables were of equal importance to the job under consideration. However, if a difference did exist, it would be of prime importance to learn where the characteristics differed. This knowledge, together with a ranking of the variables, can be gained

through the separation of the characteristics into significance groups, i.e., groups of characteristics consisting of one or more members, no member of which differs significantly from the other members of its group, but each member of which differs significantly from all the characteristics in the other groups.

To accomplish the ranking and separation, the sample means $\bar{X}_{.j}$ and the standard error of the mean $s_{\bar{X}_{.j}}$ are used in a manner similar to that described in Ref. 4 and Ref. 5. The procedure used to accomplish the two functions above is described below:

1. The sample means of the characteristics are computed as

$$\bar{X}_{.j} = \frac{1}{N} \sum_{i=1}^{N} X_{ij} ,$$

and the standard error of the mean for all characteristics as

$$s_{\bar{X}_{.j}} = \sqrt{\frac{\sum_{j=1}^{k} \sum_{i=1}^{N} (X_{ij} - \bar{X}_{.j})^2}{kN(N-1)}} .$$

Note that if N were to vary from column to column (characteristic to characteristic), $s_{\bar{X}_{.j}}$ would vary inversely to $N(N-1)$. However, this study was conducted under the assumption that all subjects would rate all the variables. Therefore, N would not vary, and the standard error of the mean would be the same for all characteristics.

2. The k means are arranged in ascending order of value.

3. Table E of Ref. 5 is entered. Listed from the table are the $(k-1)$ ranges tabulated for the arguments $\alpha = 0.05$ and $n_2 = k(N-1)$.

The ranges, in ascending order, correspond to the arguments p = 2, 3, . . . , k, where p equals the rank of the 2nd, 3rd, . . . , kth largest means. In this particular study, since N(k - 1) was much greater than 100, the largest finite argument n_2 listed, n_2 was assumed to be infinite. In addition, linear interpolation was used to compute ranges for any argument p not listed in the table.

4. Each of the ranges obtained above is multiplied by $s_{\bar{X}.j}$ to form the (k - 1) least significant ranges between pairs of means.

5. Finally, each pair of means is compared by taking the difference of the two means and comparing that difference to the least significant range applicable to that pair, i.e., the first pair to be tested are the largest versus the smallest, using the LSR for p = k; the second pair, the largest versus the second smallest, with p = k - 1; . . . ; the largest versus the second largest, with p = 2; then the second largest versus the smallest, with p = k - 1; and so on, until finally, the second smallest is compared to the smallest, with p = 2. In this way, all k(k - 1)/2 possible pairs of means are compared. For any pair, if the difference is greater than or equal to the least significant range applicable to that pair of means, the means are considered significantly different from one another and are placed in different significance groups. The total number of significance groups thus may range from one--where no difference at all is discerned--to a maximum of k--where each mean is different from each other mean.

Note that the procedure described above would be employed only if the Friedman test revealed a statistical difference between the

variables. Note further that the ordering of the individual means would be invalid, except that when a mean is placed in a higher significance group, it indicates that that characteristic is more important than another characteristic whose mean has been placed in a lower group. Thus, the several groups of characteristics would be ordered from the highest to the lowest, with the characteristics included in a particular group not differing significantly from one another.

IV. THE DATA ANALYSIS PROGRAM

In the analysis of the response to the proposed questionnaire by the workers in a particular job, hand computation would prove an herculean, if not impossible, task. If one then multiplies such a task by the hundreds of job specialties within the Marine Corps, the job assumes even more gigantic proportions. Fortunately, however, the electronic computer can reduce the problem to a size more easily handled. Therefore, a computer program, using FORTRAN IV as a language, was developed to perform the tasks described in Chapter III and to print the results of such computations. As no actual data were available at the time the program was developed, simulated data were used to test the program.

A. FEATURES OF THE PROGRAM

Program development and testing were accomplished on the IBM 360 computer at the Naval Postgraduate School. The initial phase of the program--computation of the Friedman Statistic--is performed through the use of the system-supplied subroutine TWOAV which, in turn, uses the system-supplied subroutine RANK to rank the responses of each subject to each characteristic. The computed Friedman Statistic is then compared to the critical value 75.352 discussed previously in this paper. If the statistic proves not significant, such information is printed and the next set of data is considered. If, on the other hand, the Friedman

statistic proves significant, the program switches to the second phase of the analysis, grouping the characteristics by significance. This phase, developed by this investigator, automatically prints the sample means of the characteristics in descending order, simultaneously separating them into significance groups. The arrays in the program were arranged to handle sets of data such that the total number of subjects responding is equal to forty, and the total number of human characteristics treated is equal to fifty-eight. Additionally, the forty subjects were separated into four categories by military rank, category I containing privates, privates first class and lance corporals, category II, corporals and sergeants, category III, staff sergeants and gunnery sergeants, and category IV, master sergeants, first sergeants, master gunnery sergeants and sergeants major. This added dimension was used to allow the program to perform five cycles on each set of data, analyzing each category of the set. This dimension could have been expanded to more categories, reduced to fewer categories, or eliminated entirely. In addition, dimensions could have been added for time on the job and time in the occupational field. All of these changes would entail alterations to the developed program, but these alterations would be negligible when compared to the ease of computation achieved. A flow chart of the program is shown in Figure 1.

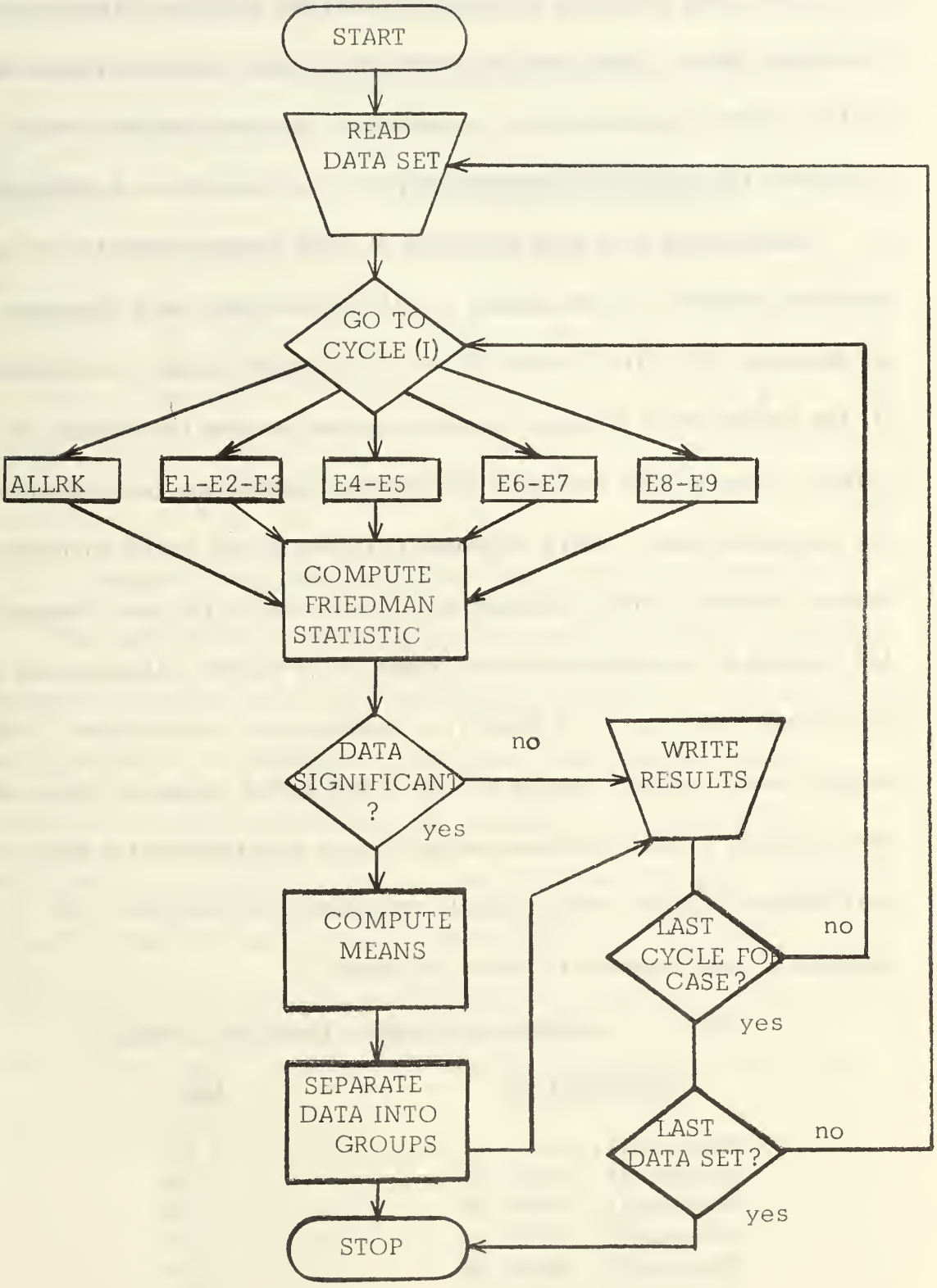

Figure 1. Flow chart for the Human Factors Data Analysis Program.

B. TESTING OF THE PROGRAM

Five data sets were generated to test the validity of the program described above. Each data set consisted of forty subjects rating each of fifty-eight characteristics. In addition, the forty subjects were separated into the four categories of rank, ten subjects to a category.

Each of the data sets consisted of 2320 ratings generated in the following manner: In set number 1, all of the ratings were distributed as Binomial (2,1/2)+1/2 with E(X) = 1 1/2; in sets number 2 and number 3, the ratings were arranged in a non-random fashion into blocks of ratings, some blocks including all four rank categories and several of the characteristics, others including only one or two of the characteristics, and still others including only one or two of the rank categories but several of the characteristics, each of the blocks following one of six distributions shown in Table I; in sets number 4 and number 5, the ratings were in blocks similar to sets 2 and 3, but values of which were deterministic in nature wherein entire blocks consisted of the same value with different values seeded lightly throughout the data sets. An example of such seeding is shown in Figure 2.

Table I. Distributions used in Data Sets 2 and 3.

DISTRIBUTION	E(X)
Binomial(1,.05)	0.05
Binomial(1,.25)+0.25	0.50
Binomial(1,.50)+0.50	1.00
Binomial(2,.50)+0.50	1.50
Binomial(2,.50)+1.00	2.00
Binomial(1,.95)+1.50	2.45

It must be remembered that the data with which this investigator was working were the integer values, 0, 1, 2, and 3, so any numbers generated by the distributions above were converted to the nearest integer in the range above.

SUBJECTS	HUMAN CHARACTERISTICS											
	(1)	(2)	(3)	. . .	(13)	(14)	(15)	. . .	(36)	(37)	. . .	(58)
1	3	3	2		2	2	0		1	2		2
2	3	3	2		2	1	0		1	2		2
3	3	2	2		2	2	0		1	2		2
4	3	3	2		2	2	1		1	2		3
.	.	.	.		.	.	.		.	.		.
.	.	.	.		.	.	.		.	.		.
.	.	.	.		.	.	.		.	.		.
40	3	3	2		2	2	0		1	2		2

Figure 2. An example of the type of data used in Sets 4 and 5.

As could be expected, the data in Set 1 produced no significant difference between any of the characteristics overall or within any of the rank categories. Furthermore, since Sets 2 and 3 consisted of probibilistic data cutting across the boundaries between rank and characteristic, some differences in the significance groups calculated overall and within rank categories were apparent. Additionally, since Sets 4 and 5 consisted of data with almost nonexistent variation within blocks, Sets 4 and 5 generated relatively more distinct significance groups than did Sets 2 and 3.

V. CONCLUSION

In studying the collection and analysis of data relating to the human characteristics of a worker, a spectrum of methods and combinations of methods present themselves to the investigator. When collecting the data, is it better for a trained observer to study the duties of a selected number of men and rate the necessity of each of the human factors he observes, or should the workers themselves rate such characteristics? What parameters should be used in the analysis of the data?

This investigator concluded that data such as was to be treated in this study can best be collected by the workers themselves completing the proposed questionnaire, assisted and guided by a trained observer. Each observer can collect only a finite amount of information. Since each occupational field, even the most prosaic, consists of a sizable number of job specialties, a platoon of such observers could follow a worker or workers around for a month and still not observe every task contributing to that job. On the other hand, the workers, despite their skill on the job, could very probably take many of the human factors listed in the questionnaire for granted and discount their importance. Therefore, the response of the workers, guided and supplemented by trained analysts, appears to be the correct method of data collection. With this stipulation in mind, the questionnaire proposed in this paper

was designed to be completed by the men occupying the positions under consideration. Additionally, space was reserved to enter any characteristic the responder feels is not adequately defined in the form.

The Friedman Two-Way Analysis of Variance used to test for a statistical difference between characteristics would seem to be the most powerful test available, considering the nature of data and the unwillingness of the investigator to assume a distribution of such data. Friedman, in Ref. 10, reported that the analysis of fifty-six sets of data compatible with analysis by the F test, using both the F test and the Friedman Statistic, could not differentiate between the two tests regarding power. It may be safe to assume, then, that the Friedman test is comparable to the F test in power and perhaps superior to the F test in analyzing the highly discrete data of this study.

The method presented for separating the characteristics into groups is open to question. However, since the Friedman test establishes a difference between variables prior to employment of subject method, and since the sample mean is an unbiased estimator of the population mean, the method presented appears adequate to its function.

A final word is in order about the blocks of data to be analyzed. As was suggested previously, parameters can be added to the data analysis program to separate the data along the lines of military rank and experience. By separating the data into such blocks, one may determine what human traits are necessary to a corporal, for example, which may not be required by a master sergeant. Then, too, certain characteristics may be of prime importance throughout one's career.

In many occupational fields, lower ranking men perform jobs which differ greatly from those performed by non-commissioned officers. Because of this, and because the more menial tasks are performed by the lower ranks, the physical traits may outweigh the mental, but become less important as the man progresses to jobs more responsible, but less physically taxing. The proposed system should give some indication of this, and, in addition, show what education or training is needed at various points in a Marine's career. Such information should prove invaluable to the Marine Corps' readiness and efficiency.

APPENDIX A

WORKER CHARACTERISTICS
(As developed by the Canadian Armed Forces)

JOB TITLE

Indicate the amount of each characteristic required of the worker in order to do the job satisfactorily by putting an X in the appropriate column. Following are the definitions of each level:

1 The characteristic is not required for satisfactory performance of the job.

2 A medium to very low degree of the characteristic is required in some elements of the job.

3 An above-average degree of the characteristic is required either in numerous elements of the job or in the major or most skilled element.

4 A very high degree of the characteristic is required in some element of the job.

When in doubt between 4 and 3, rate 3; when in doubt between 3 and 2, rate 3; when in doubt between 2 and 1, rate 2. If some characteristic not on this list is required, write it in, rate it, and define it briefly at the bottom of the form.

1. Work Rapidly for Long Periods - Ability to work at high speed during the entire working period. It does not involve consideration of energy output, but simply rate of performance. Working period is the time normally devoted to work activity; It may vary with industries, plants and processes. An additional characteristic should be used for occupations involving "the ability to work rapidly for short periods."

Considerations are: pacing by machine or management; pay incentives; repetitiveness of work; number and complexity of units produced.

2. Strength of Hands - Ability to perform work requiring strong muscles in fingers, hands, wrists, and forearms such as are primarily involved in squeezing, bending, pulling, twisting, shaping, turning, or gripping objects. It does not involve use of arm from elbow to shoulder as a primary muscular activity.

Considerations are: weights handled; frequency and duration of handling; rapidity of movement; distance objects are moved.

3. Strength of Arms - Ability to perform work requiring strong muscles in the arms from elbow to shoulder, such as are primarily involved in lifting, swinging, pushing, pulling, carrying, or throwing objects.

Considerations are: weights handled; frequency and duration of handling; rapidity of movement; distance objects are moved.

4. Strength of Back - Ability to perform work requiring strong muscles in the back and shoulders such as are primarily involved in such activities as lifting objects from the floor, pushing with back and shoulders, or striking blows with sledge hammer.

Considerations are: weights handled; frequency and duration of handling; rapidity of movement; distance objects are moved.

5. Strength of Legs - Ability to perform work requiring strong, well-developed muscles in the legs and thighs, ankles, and feet, such as are primarily required in such activities as lifting objects by knee action, operating pedals requiring pressure, gripping or bracing with the knees and legs, or extensive climbing, walking, kneeling, standing or crawling.

Considerations are: weights handled; frequency and duration of handling; rapidity of movement; distance objects are moved; extent of climbing, walking, kneeling, standing, or crawling involved.

6. Dexterity of Fingers - Ability to move the fingers, or manipulate objects with the fingers, rapidly or accurately. This is not to be confused with the use of fingers as part of whole-hand movement.

Considerations are: complexity and speed of movements; fingers of one or both hands used; size of objects handled; accuracy of movements required.

7. Dexterity of Hands and Arms - Ability to move hands and arms quickly or accurately.

Considerations are: complexity, frequency, repetitiveness of movements; both hands or one used; accuracy required.

8. Dexterity of Feet and Legs - Ability to move the feet and legs rapidly or accurately.

Considerations are: complexity, frequency, repetitiveness of movements; use of both feet or legs, or use of one foot of leg; accuracy necessary.

9. Eye-Hand Coordination - Ability to control accurately the movements of the hands by what the eyes see. It does not necessarily involve speed.

Considerations are: complexity, frequency, repetitiveness of movements.

10. Foot-Hand-Eye Coordination - Ability to control accurately the simultaneous movements of hands and feet by what the eyes see. This does not necessarily involve speed. Eye-hand coordination should always be rated when this item is rated. Foot-eye coordination (not involving the hands), foot-hand coordination (not involving the use of the eyes), and leg-hand-eye coordination (not involving the feet) should be entered as additional characteristics.

Considerations are: rapidity, complexity, and frequency of movements.

11. Coordination of Independent Movements of Both Hands - Ability to move the right and left hands independently and at the same time; doing one thing with one hand while doing something else with the other hand. Does not necessarily involve vision.

Considerations are: rapidity, frequency, and complexity of movements; direction of movements; difference between movements of the two hands.

12. Estimate Size of Objects - Ability to make accurate judgments of dimensions such as length, breadth, depth, height, or thickness, or to estimate general over-all size or area. Mechanical aids may be used for determining bases for arrival at final estimate. Special sense and discriminations (such as vision, hearing, touch discrimination, etc.) used in arriving at estimations of size should be rated in addition when this item is rated. Estimation of distance, except when part of the estimation of speed of moving objects (no. 15), should be entered as an additional characteristic.

Considerations are: complexity of objects; number of dimensions considered; variability of estimations required; frequency and rapidity of estimations made; extent to which mechanical aids are used.

13. Estimate Quantity of Objects - Ability to make accurate judgments of quantity or capacity of objects in terms of weight, number or volume. Mechanical aids may be used for determining bases for arriving at final estimate. Special senses or discriminations (such as vision, muscular discrimination, etc.) used in arriving at estimations of quantity should be rated in addition when this item is rated.

Considerations are: variability of estimations required; complexity of objects; frequency and rapidity of estimations required; extent to which mechanical aids are used.

14. Perceive Form of Objects - Ability to distinguish whether objects are of the correct shape of outline, or to conceive generally in terms of shape. Mechanical aids may be used for determining bases for arriving at final estimate. Includes ability to perceive spatial relations. Special senses, estimations, or discriminations (such as vision, touch discrimination, etc.) used in the perception of form, should be rated in addition when this item is rated.

Considerations are: complexity of form; rapidity and frequency of perceptions required; comparisons with concrete standard or a mental concept of standard; extent to which mechanical aids are used.

15. Estimate Speed of Moving Objects - Ability to make accurate judgments of the rate of motion of a moving object in relation to other moving objects or to a fixed point. Mechanical aids may be used for determining bases for arriving at final estimate. The estimation of speed involves the estimation of both time and distance. When so involved, these characteristics should not be rated separated. However, if the estimation of either time or distance, not in relation to speed, is involved in an occupation, an additional characteristic should be used.

Considerations are: frequency, rapidity, and complexity of estimations; variability of estimations required; extent to which mechanical aids are used.

16. Keenness of Vision - Ability to perceive or recognize objects, or locate points at a distance, or to make accurate discriminations through the use of vision. Any estimations or perceptions (such as of form, size, etc.) arrived at by use of keen vision should be rated in addition when this item is rated.

Considerations are: fineness of distinctions required; frequency, rapidity and complexity of discrimination involved; conditions of work; aids to vision used.

17. Keenness of Hearing - Ability to distinguish accurately, differences or similarities in the pitch, intensity, or quality of sounds, or to recognize a particular sound. Any of the estimations arrived at by the use of keen hearing should also be rated when this item is rated.

Considerations are: conditions of work; frequency, rapidity, and complexity of sound cues; fineness of distinctions required.

18. Sense of Smell - Ability to distinguish similarities or differences in the intensity or quality of odors, or to recognize a particular odor. Any of the estimations arrived at by the use of the sense of smell should be rated in addition when this item is rated.

Considerations are: fineness of distinctions required; frequency and rapidity of odor identification; intensity of odors dealt with.

19. Sense of Taste - Ability to distinguish accurately differences or similarities in the intensity or quality of tastes, or to recognize a particular taste. Any estimations arrived at through the sense of taste should be rated in addition when this item is rated.

Considerations are: fineness of distinctions required; intensity and complexity of tastes dealt with; frequency and rapidity of tasting.

20. Touch Discrimination - Ability to judge accurately through the use of touch; sensitivity of fingers or other parts of the body to smoothness, roughness, contour, and other surface qualities of objects. This does not involve pressure sense (see no. 21). It does not include estimation of temperature or moisture by touch. These should be rated as additional characteristics where necessary. Any estimations or perceptions (such as form, quality, etc.) arrived at by the use of touch discrimination should be rated in addition when this item is rated.

Considerations are: frequency, rapidity and complexity of discriminations; fineness of distinctions required.

21. Muscular Discrimination - Ability to make judgments on the basis of muscular sensitivity, such as is required in estimating weight by lifting, in estimating resistance by pushing or pulling, in estimating position of or guiding body members without using eyes, or in regulating pressure of body members as in the use of pedals, hammering, etc. Estimations made through the use of muscular discrimination should always be rated in addition when this item is rated.

Considerations are: frequency, rapidity, complexity of discriminations required; fineness of distinctions necessary.

22. Memory for Details (Things) - Ability to remember or recall concrete details, such as size, color, price, quantity, order of comples assembly, job specification items, etc. This is distinguished from memory for ideas (no. 23) which involves ability to remember theory behind concrete facts.

Considerations are: number and complexity of items to remember; length of time items must be remembered; frequency and rapidity of memory changes required.

23. Memory for Ideas (Abstract) - Ability to remember principles, ideas, or theories behind a job, including memory for plans, policies, processes, etc. It is distinguished from ability to remember details (no. 22) which merely involves remembering concrete items.

Considerations are: complexity of job; frequency of changes in job situation; length of time remembered.

24. Memory for Oral Directions - Ability to remember a series of directions or other information given orally.

Considerations are: length of time remembered; complexity of material remembered; frequency and rapidity of changes in content of material to be remembered.

25. Memory for Written Directions - Ability to remember a series of directions or other information which has been read.

Considerations are: complexity and amount of material to be remembered; length of memory required; frequency and rapidity of changes in content of written directions; accessibility of material for referral.

26. Arithmetic Computation - Ability to do arithmetic or higher mathematics. Occupations which involve analysis or interpretation of quantitative statistical data, but which do not actually involve arithmetic computation should also be rated for this item.

Considerations are: accuracy and rapidity of arithmetic calculation required; calculation aids used; level of mathematics involved.

27. Intelligence - Ability to reason and make judgments. Intelligence is an over-all term referring to problem-solving ability and involving reasoning, judgment, memory, attention, alertness, versatility, inventiveness, etc. This characteristic should be rated in addition to other characteristics which may be incidental to problem-solving ability such as ability to plan, ability to make decisions, adaptability, etc.

Considerations are: complexity of problems; responsibility of job.

28. Adaptability - Ability to adjust readily to new and changing situations in the job. A sum-total of physical, temperamental and intellectual flexibility. Not to be confused with emotional stability, intelligence, initiative or attention to many items.

Considerations are: complexity of job; frequency and rapidity of changes in job details; speed with which adjustment is required.

29. Ability to Make Decisions - Ability to consider the evidence and reach some conclusion without undue delay.

Considerations are: complexity of evidence; frequency and rapidity of decisions required; variation in job situation; responsibility of job and consequences of decisions.

30. Ability to Plan - Ability to recognize and comprehend what things are to be done to achieve a specific end, and to decide upon, set up, and coordinate procedures for attaining that result; ability to organize ideas or things.

Considerations are: complexity of problems met; responsibility of job; variability of work situation.

31. Initiative - Ability to recognize the implications of a work situation and to act upon the needs of the situation without specific instructions.

Considerations are: complexity, responsibility and variability of work; consequences of actions.

32. Understanding of Mechanical Devices - Ability to comprehend and to put into use the principles of mechanical structure and operation, mechanical insight or ingenuity. This refers to problem-solving ability applied to machines, equipment, apparatus, tools, and other devices used in industry. Understanding general structural principles and methods, not concerning machines, should be rated as an additional characteristic.

Considerations are: number and variety of principles involved; complexity of devices involved; direct application of theory and construction, or creative use in design.

33. Attention to Many Items - Ability to keep the mind on many parts of a job at one time, or to shift attention from one thing to another readily. This is not to be confused with memory for details. Memory for details concerns the ability to remember or recall items. Attention to items, although it may also involve memory for those items, should be considered solely in terms of application of attention.

Considerations are: complexity and accuracy of job and number of items; frequency and rapidity of shifts of attention required; working conditions affecting attention.

34. Oral Expression - Ability to express one's self orally in a clear and effective manner. Any activity requiring spoken words should be considered for rating under this characteristic, and its use should not be limited to sales work, lecturing, etc.

Considerations are: responsibility of job and consequences of spoken words, whether directly before audience or through mechanical reproduction; purpose of spoken words.

35. Skill in Written Expression - Ability to present information or ideas clearly in writing. Do not confine this rating to creative writing only, but rate this item for any job involving the development of written material.

Considerations are: nature and purpose of written material; classes of persons receiving it; responsibility and accuracy of job.

36. Tact in Dealing with People - Ability to use diplomacy in human relations of any sort so as to obtain or retain respect, good will, cooperation, etc. This should be used for rating jobs involving either public contact work or personnel work within a plant. Do not confuse with general liability to meet and deal with people, involving tact at times. Reserve "tact" for the rating of ability to handle "ticklish" situations in dealing with people.

Considerations are: frequency of situations requiring tactful handling; responsibility of job; consequences of actions.

37. Memory of Names and Persons - Ability to recognize or recall names or persons by means of appearance, voice, or other information known about them. Rate the item for any job in which identification of people by name is required.

Considerations are: numbers of persons to be remembered; amount of direct contact assisting in memory; type of information assisting in memory; responsibility of job.

38. Personal Appearance - Personal looks, grooming, attire, neatness, or attractiveness. Rate for any job in which some factor of personal appearance is involved in the work.

Considerations are: consequency and significance of personal appearance on the job.

39. Concentration Amidst Distractions - Ability to carry on a job amidst noise, interruptions, or other disturbing influences. Do not confuse with attention to many items, although distractions may be a contributing factor to the rating of attention.

Considerations are: complexity of job; type and degree of distraction; responsibility of work; and accuracy required.

40. Emotional Stability - Ability to remain calm and self-controlled under all conditions.

Considerations are: consequences of actions, and responsibility and accuracy of job; frequency and rapidity of situation adjustments necessary.

41. Work Under Hazardous Conditions - Ability to carry on work under conditions of hazard which may result in physical injury. Do not confuse with emotional stability, but rate as a separate factor.

Considerations are: extent of injury possible or probable; safety measures operating; responsibility of job; effect of actions on other workers.

42. Estimate Quality of Objects - Ability to judge the quality of workmanship or of material. Since the estimation of quality usually involves the application of one of the special senses, or the ability to make estimations and discriminations of a more specific nature, rate all such related items in addition to this characteristic.

Considerations are: responsibility, complexity and accuracy of job; finality of judgment made; frequency and rapidity of judgments required.

43. Work Under Unpleasant Physical Conditions - Ability to work on job under conditions affecting physical comfort. Qualify each rating of this item. Do not consider possibility of becoming accustomed to unpleasantness when rating this item. Unpleasant physical conditions or surroundings include bad odors, noise, vibration, dust, dirt, fumes, wetness, humidity, extreme heat or cold, wide temperature variation, exposure to acids, unpleasant sights, etc.

44. Color Discrimination - Ability to distinguish or recognize similarities or differences in colors, or in the shades, tints, or other values of the same color; to recognize a particular color sought; or to recognize and create harmonious color combinations; or to mix or match colors. When an estimation of temperature is arrived at through color discrimination, this characteristic should be rated, and the estimation of temperature should be rated as an additional characteristic.

Considerations are: degree of distinction required, rapidity of work; standard of identification available; frequency of discrimination required.

45. Ability to Meet and Deal with the Public - Ability to meet and deal with the public, and to establish and maintain agreeable relations. This includes face-to-face, telephonic or other contacts with the public. It does not include factors involved in "tact in dealing with people" (no. 36).

Considerations are: number and type of contacts, responsibility of the job and consequences of contact.

46. Height - Specific requirements of height within fairly definite limits due to elements performed on the job. Do not consider this item as the height requirements stated by employers, but rate it only in light of work done elements placing definite height requirements upon the worker.

47. Weight - Specific requirement of weight within fairly definite limits, due to elements performed on the job. Do not consider this item as the weight requirements stated by employers, but rate it only in the light of work done elements placing definite weight requirements upon the worker.

48. Teamwork - Requirement to integrate individual work performance with work activities or a group in work situations where group rather than individual effort is necessary for adequate performance of the required duties and tasks. Work situations in which personal prominence is subordinated to the efficiency of the group or team.

49. Leadership - The requirement to direct or command individuals engaged in group activities. Inherent is the ability to motivate subordinates so that they will willingly produce desired results; ability to plan operations, maintain internal communications; performance of assigned mission; ability to exercise necessary administrative and disciplinary controls over subordinates without adverse effect to individual and group work performance.

50. Dependability - Requirement to produce work results that can be relied upon. Inherent is the ability to perform assigned duties and tasks in such an efficient manner and to so consistently produce required results that supervisor and co-workers have complete confidence and trust in ability to successfully complete all work assignments.

APPENDIX B

WORKER CHARACTERISTICS QUESTIONNAIRE
(As developed in this paper)

Rank:_____ MOS:_____ Experience in MOS: Years_____Months_____

Present Job: _____

Experience in Present Job: Years_____Months_____

The purpose of this questionnaire is to determine what human characteristics are necessary in the performance of your job. Read the definition of each characteristic carefully and indicate, by placing an "X" in the appropriate column, the degree to which you feel that characteristic necessary in the successful performance of your job. Following are the definitions of the degrees of necessity:

(0) The characteristic not required.
(1) The characteristic occasionally required.
(2) The characteristic frequently required, but not on a regular basis.
(3) The characteristic regularly required, OR, if not regularly required, exceptional importance to your job.

WORKER CHARACTERISTICS

I. PHYSICAL CHARACTERISTICS	Level Required (0)	(1)	(2)	(3)
A. STRENGTH: Rate only strength, not muscular endurance. Consider the size, weight and bulkiness of objects handled and the pressure necessary to operate controls and tools.				
1. Finger, Hand, Wrist and Forearm Strength - Used to squeeze, bend, pull, twist, shape or grip objects.	☐	☐	☐	☐
2. Upper Arm Strength - Used to lift, swing push, pull, carry or throw objects.	☐	☐	☐	☐
3. Back and Shoulder Strength - Used to lift objects from the floor, move objects with the back and shoulders or swing heavy tools to strike objects.	☐	☐	☐	☐

Level Required
(0) (1) (2) (3)

4. Leg, Foot and Ankle Strength - Used to lift objects with knee action, operate pedals with pressure, grip or brace with the knees, or climb, kneel, walk or stand with loads. ☐ ☐ ☐ ☐

B. STAMINA: Rate combined muscular endurance, the ability to sustain strength over a period of time, and circulo-respiratory endurance, commonly called wind, the ability to sustain vigorous activity over a period of time. Consider pacing by machines or superiors, the frequency, rapidity and duration of movement, the extent of the vigorous activity, and whether the duraction of the activity is of known or indeterminate length.

5. Rapid Work for a Series of Short Periods. ☐ ☐ ☐ ☐

6. Rapid Work for Long Periods. ☐ ☐ ☐ ☐

7. Rapid Work for Indefinite Periods. ☐ ☐ ☐ ☐

8. Heavy Work for a Series of Short Periods. ☐ ☐ ☐ ☐

9. Heavy Work for Long Periods. ☐ ☐ ☐ ☐

10. Heavy Work for Indefinite Periods. ☐ ☐ ☐ ☐

C. DEXTERITY: Rate the skill or adroitness in the movement of the subject parts of the body. Consider the speed, complexity and repetitiveness of movements, the accuracy required, and whether or not all digits or limbs are used in the movement.

11. Finger Dexterity - The movement of the fingers necessary to manipulate objects. ☐ ☐ ☐ ☐

12. Hand and Arm Dexterity (Including the fingers when used as part of the whole) - The movement of the hands and arms necessary to manipulate objects. ☐ ☐ ☐ ☐

13. Foot and Leg Dexterity - The movement of the feet and legs necessary to manipulate objects. ☐ ☐ ☐ ☐

Level Required
(0) (1) (2) (3)

D. COORDINATION: Consider the frequency, complexity and repetitiveness of movements.

14. Eye-Hand Coordination - Used to control the hand by using vision. ☐ ☐ ☐ ☐

15. Foot-Eye-Hand Coordination - Used to control, simultaneously, the feet and hands by using vision. ☐ ☐ ☐ ☐

16. Coordination of the Independent Movement of Both Hands - Used to control, simultaneously and independently, both hands, with or without the use of vision. The two hands may simultaneously perform different tasks. Additional considerations include the distance the hands move and the differences in actions of the hands. ☐ ☐ ☐ ☐

17. Foot-Eye Coordination - Used to control the feet by using vision. ☐ ☐ ☐ ☐

18. Foot-Hand Coordination - Used to control the feet and hands simultaneously without using the eyes. ☐ ☐ ☐ ☐

E. SIZE CONSIDERATIONS: Any boundaries on physical size necessitated by the task performed. Do not rate arbitrary limitations imposed by regulation or edict.

19. Height. Fill in any limits_____. ☐ ☐ ☐ ☐

20. Weight. Fill in any limits_____. ☐ ☐ ☐ ☐

F. ABNORMAL WORKING CONDITIONS.

21. Unpleasant Conditions - Must you work under conditions affecting physical comfort, including bad odors, excessive noise, vibration, dust, dirt, fumes, moisture, high humidity, extremes or constant fluctuations or a wide range in temperature, and exposure to acids or unpleasant sights? ☐ ☐ ☐ ☐

22. Hazardous Conditions - Must you work under conditions affecting your physical safety? ☐ ☐ ☐ ☐

Level Required
(0) (1) (2) (3)

G. VISION.

23. General Visual Acuity - Used to perceive or recognize objects, locate points at a distance or make accurate discriminations using vision. ☐ ☐ ☐ ☐

24. Color Discrimination - Used to distinguish similarities and differences in colors or shades thereof, create harmonious color combinations, or mix or match colors. ☐ ☐ ☐ ☐

H. HEARING.

25. General Keenness of Hearing - Used to recognice particular sounds and distinguish similarities and differences in the pitch, intensity and quality of sounds. ☐ ☐ ☐ ☐

I. SMELL.

26. Sense of Smell - Used to recognize particular odors or discriminate differences and similarities in the quality or intensity of odors. ☐ ☐ ☐ ☐

J. TOUCH.

27. Touch Discrimination - Used to accurately judge smoothness, roughness, temperature or other surface qualities, using the sense of touch. ☐ ☐ ☐ ☐

28. Muscular Discrimination - Used to make judgments based on muscular sensitivity, such as estimating weight or resistance by lifting, pushing or pulling, or guaging position or guiding body members without the use of vision. ☐ ☐ ☐ ☐

K. TASTE.

29. Sense of Taste - Used to accurately distinguish similarities and differences in the intensity or quality of tastes, recognize particular tastes, or blend tastes. ☐ ☐ ☐ ☐

Level Required
(0) (1) (2) (3)

L. VISUAL - JUDGMENTAL ACTIVITIES: Those activities involving judgments requiring the use of vision. Consider the complexity of the objects perceived, the frequency and rapidity of the required observations, their variability, and any mechanical aids used.

30. Size Estimation - Must you make accurate judgments of dimensions, such as height, weight, depth, breadth, or tickness, or of over-all size or area? ☐ ☐ ☐ ☐

31. Quantity Estimation - Must you make accurate judgments of the number or capacity of objects? ☐ ☐ ☐ ☐

32. Speed Estimation - Must you make accurate judgments of speed, involving the estimation of time and distance? ☐ ☐ ☐ ☐

33. Quality Estimation - Must you be able to judge the quality of workmanship or material? Such estimation may involve the use of touch, taste, smell or hearing, as well as vision. ☐ ☐ ☐ ☐

34. Form Perception - Must you correctly distinguish shape or outline, or generally perceive form? ☐ ☐ ☐ ☐

II. MENTAL SKILLS

A. MEMORY: Rate the capacity of the mind to store images for future reference. Consider the number and complexity of images, the rate at which they are acquired and the length of time the images must be remembered.

35. Memory for Concrete Details. ☐ ☐ ☐ ☐

36. Memory for Ideas, Theories, Plans, Processes or Policies. ☐ ☐ ☐ ☐

37. Memory for Oral Directions. ☐ ☐ ☐ ☐

38. Memory for Written Directions. ☐ ☐ ☐ ☐

39. Memory for Names and Persons. ☐ ☐ ☐ ☐

Level Required
(0) (1) (2) (3)

B. LEARNED CHARACTERISTICS.

40. Arithmetic Computation - Used to perform arithmetic calculations or higher mathematics. ☐ ☐ ☐ ☐

41. Planning Ability - The ability to recognize and comprehend the steps necessary to achieve specific ends, decide upon, set up and coordinate plans, and organize ideas or things. ☐ ☐ ☐ ☐

42. Mechnical Ability - The ability to understand the principles of mechnical structure and operation and solve problems involving tools and machines. ☐ ☐ ☐ ☐

43. Oral Expression - In speaking, the ability to express oneself clearly and effectively. ☐ ☐ ☐ ☐

44. Written Expression - In writing, the ability to express oneself clearly and effectively. ☐ ☐ ☐ ☐

III. PSYCHOLOGICAL CONSIDERATIONS

45. Attention to Many Items - Must you keep in mind many parts of one job, although required to repeatedly and constantly to shift your attention from part to part? ☐ ☐ ☐ ☐

46. Adaptability - Must you adjust readily to new situations. ☐ ☐ ☐ ☐

47. Decision-Making Ability - The ability to consider evidence and, without unnecessary delay, reach a proper conclusion. ☐ ☐ ☐ ☐

48. Initiative - The ability to recognize a need for a change in procedures and actions and, in the absence of specific instructions, to accomplish such change. ☐ ☐ ☐ ☐

49. Tact - The use of diplomacy in dealing with people to achieve certain ends. Rate this characteristic degree (0) if only normal consideration of others is needed. A high rating will indicate jobs in which unusual tact is required. ☐ ☐ ☐ ☐

	Level Required (0)	(1)	(2)	(3)
50. Personal Appearance - The need, occasionally or more often, to maintain a level of neatness, grooming and attire above and beyond that necessary for a good Marine.	☐	☐	☐	☐
51. Concentration amid Distractions - Used in continuing to work amid noise, interruptions or other distractions.	☐	☐	☐	☐
52. Emotional Stability - Used to maintain self-control, to remain calm at all times.	☐	☐	☐	☐
53. Dealing with the Public - Must you meet and deal with the public, not necessarily exercising abnormal tact?	☐	☐	☐	☐
54. Teamwork - Must you subordinate your individual prominence to aid your team or unit to operate efficiently?	☐	☐	☐	☐
55. Leadership - The ability to cause subordinates to willingly produce desired results through a combination of superior knowledge, thoughtfulness, courage and exemplary personal performance.	☐	☐	☐	☐
56. Dependability - The ability to produce desired results at the proper time to such an extent that both one's superiors and subordinates may depend on his performance.	☐	☐	☐	☐
57. Physical Courage - The ability to do the necessary regardless of possible harmful physical consequences.	☐	☐	☐	☐
58. Moral Courage - The ability to do what is right, although what is right is not necessarily legal or popular.	☐	☐	☐	☐
59. List below any required characteristics not listed above and indicate the degree of necessity required.	☐	☐	☐	☐
	☐	☐	☐	☐

APPENDIX C

HUMAN FACTORS DATA ANALYSIS COMPUTER PROGRAM

SPECIFICATION, INITIALIZATION AND DATA INPUT

```
      INTEGER ORDMN
      DIMENSION WC(58,10,4),WCSIM(40,58),WCSIMA(40,58),
     1WCSQ(40,58),SIGRG(57),ZBAR(58),XBAR(58),RBAR(58),
     2NGRP(58,58),NUMERO(5),ORDMN(58),R(40,58),RR(40,58),
     3WCA(10,58),DIFF(58),W(116),XLSR(57)
      DATA SIGRG/2*4.62,6*4.61,2*4.60,2*4.59,4.58,2*4.57,
     14.56,2*4.55,2*4.54,4.53,2*4.52,4.51,2*4.50,4.49,
     22*4.48,2*4.47,4.46,2*4.45,4.44,2*4.43,4.42,4.41,4.40,
     34.38,4.36,4.34,4.33,4.31,4.29,4.26,4.23,4.20,4.17,
     44.14,4.09,4.04,3.98,3.90,3.80,3.64/
9999  READ(5,1)LE3,LE5,LE7,LE9,NC,NR,IFLAG,NSIM
1     FORMAT(8I5)
      IF(IFLAG.EQ.1)GO TO 193
      DO 1984 I=1,58
      DO 1984 J=1,10
      DO 1984 K=1,4
1984  WC(I,J,K)=0.0
      DO 1914 I=1,58
      DO 1914 J=1,40
      WCSIM(J,I)=0.0
      WCSIMA(J,I)=0.0
1914  WCSQ(J,I)=0.0
      DO 1965 I=1,5
1965  NUMERO(I)=0
      DO 1999 I=1,40
      DO 1999 J=1,58
1999  R(I,J)=0.0
      READ(5,2)(((WC(I,J,K),J=1,10),I=1,58),K=1,4)
2     FORMAT(80F1.0)
300   LSGT=LE3+1
      NSGT=LE3+LE5
      LGUN=LSGT+LE5
      NGUN=NSGT+LE7
      LTOP=LGUN+LE7
      NTOP=NGUN+LE9
```

CONVERSION OF INPUT DATA TO FORMAT SUITABLE FOR SUBROUTINE

```
      DO 302 I=1,58
      DO 399 K=1,4
      IF(K.EQ.2)GO TO 350
      IF(K.EQ.3)GO TO 351
      IF(K.EQ.4)GO TO 352
      DO 303 J=1,LE3
303   WCSIM(J,I)=WC(I,J,K)
      GO TO 399
350   DO 304 J=LSGT,NSGT
304   WCSIM(J,I)=WC(I,J-LSGT+1,K)
      GO TO 399
351   DO 305 J=LGUN,NGUN
305   WCSIM(J,I)=WC(I,J-LGUN+1,K)
      GO TO 399
352   DO 306 J=LTOP,NTOP
306   WCSIM(J,I)=WC(I,J-LTOP+1,K)
399   CONTINUE
302   CONTINUE
```

```
FURTHER INITIALIZATION AND FRIEDMAN TWO-WAY ANOVA BY RANKS

      DO 307 I=1,NC
      DO 307 J=1,58
307   WCSQ(I,J)=WCSIM(I,J)*WCSIM(I,J)
229   NUM=1
369   DO 1970 I=1,58
      DO 1970 J=1,58
1970  NGRP(I,J)=0
480   DO 2999 I=1,10
      DO 2999 J=1,58
2999  RR(I,J)=0.0
      DO 5555 I=1,116
5555  W(I)=0.0
301   NG=58
      DO 1958 I=1,58
      ZBAR(I)=0.0
      XBAR(I)=0.0
      RBAR(I)=0.0
      DIFF(I)=0.0
1958  ORDMN(I)=0
      DO 1950 I=1,57
1950  XLSR(I)=0.0
      DO 234 I=1,10
      DO 234 J=1,58
234   WCA(I,J)=0.0
600   IF(NUM.EQ.2)GO TO 4003
      IF(NUM.EQ.3)GO TO 4002
      IF(NUM.EQ.4)GO TO 4001
      IF(NUM.EQ.5)GO TO 4006
      LRANK=NC
      DO 2006 J=1,58
      DO 2006 I=1,NC
2006  WCSIMA(I,J)=WCSIM(I,J)
      GO TO 2001
4003  LRANK=LE3
      DO 2005 J=1,58
      DO 2005 I=1,LE3
2005  WCA(I,J)=WCSIM(I,J)
      GO TO 2010
4002  LRANK=LE5
      DO 2004 J=1,58
      DO 2004 I=LSGT,NSGT
2004  WCA(I-LSGT+1,J)=WCSIM(I,J)
      GO TO 2010
4001  LRANK=LE7
      DO 2003 J=1,58
      DO 2003 I=LGUN,NGUN
2003  WCA(I-LGUN+1,J)=WCSIM(I,J)
      GO TO 2010
4006  LRANK=LE9
      DO 2002 J=1,58
      DO 2002 I=LTOP,NTOP
2002  WCA(I-LTOP+1,J)=WCSIM(I,J)
      GO TO 2010
2001  CALL TWOAV(WCSIMA,R,LRANK,NG,W,XR,NDF,NR)
      GO TO 2020
2010  CALL TWOAV(WCA,RR,LRANK,NG,W,XR,NDF,NR)
2020  IF(XR.GE.75.352)GO TO 3000

COUNTING BLOCK

      NUMERO(NUM)=0
      NOMER=NUM
      NUM=NUM+1
      GO TO 8000
3000  NUMERO(NUM)=1
      NOMER=NUM
      NUM=NUM+1
```

```
TRANSFER TO APPROPRIATE ANALYSIS CYCLE

      IF(NOMER.EQ.2)GO TO 3002
      IF(NOMER.EQ.3)GO TO 3003
      IF(NOMER.EQ.4)GO TO 3004
      IF(NOMER.EQ.5)GO TO 3005
3001  LLOW=1
      LHIGH=NC
      LMNOP=NC
      GO TO 4000
3002  LLOW=1
      LHIGH=LE3
      LMNOP=LE3
      GO TO 4000
3003  LLOW=LSGT
      LHIGH=NSGT
      LMNOP=LE5
      GO TO 4000
3004  LLOW=LGUN
      LHIGH=NGUN
      LMNOP=LE7
      GO TO 4000
3005  LLOW=LTOP
      LHIGH=NTOP
      LMNOP=LE9

COMPUTATION OF THE MEANS AND STANDARD ERROR OF THE MEAN

4000  DO 700 J=1,58
      SUMA=0.0
      SUMB=0.0
      DO 701 I=LLOW,LHIGH
      SUMA=SUMA+WCSQ(I,J)
701   SUMB=SUMB+WCSIM(I,J)
      XBAR(J)=SUMB/LMNOP
700   DIFF(J)=SUMA-(SUMB*SUMB/LMNOP)
      SUMDIF=0.0
      DO 702 I=1,58
702   SUMDIF=SUMDIF+DIFF(I)
      SSERR=SUMDIF/(58*(LMNOP-1))
      SERRMN=(SSERR/LMNOP)**0.5
      DO 7000 I=1,58
7000  ZBAR(I)=XBAR(I)
      DO 7001 I=1,58
      XBARLO=0.0
      DO 7002 J=1,58
      IF(ZBAR(J).LE.XBARLO)GO TO 7002
      XBARLO=ZBAR(J)
      IJK=J
7002  CONTINUE
      RBAR(I)=ZBAR(IJK)
      ZBAR(IJK)=0.0
7001  ORDMN(I)=IJK

SEPARATION OF CHARACTERISTIC MEANS INTO SIGNIFICANCE GROUPS

      DO 7003 I=1,57
7003  XLSR(I)=SERRMN*SIGRG(I)
      DO 7004 I=1,57
      LLB=I+1
      DO 7006 J=LLB,58
      RGMEAN=RBAR(I)-RBAR(J)
      IF(RGMEAN.LT.XLSR(59-J))GO TO 7005
      NGRP(ORDMN(I),ORDMN(J))=1
      GO TO 7006
7005  NGRP(ORDMN(I),ORDMN(J))=0
7006  CONTINUE
7004  CONTINUE
```

```
TRANSFER TO APPROPRIATE ANALYSIS CYCLE

8000  IF(NUMERC(NOMER).EQ.1)GO TO 8500
      IF(NOMER.EQ.2)GO TO 8002
      IF(NOMER.EQ.3)GO TO 8003
      IF(NOMER.EQ.4)GO TO 8004
      IF(NOMER.EQ.5)GO TO 8005

WRITE OUTPUT IF NO SIGNIFICANT DIFFERENCES EXIST

      WRITE(6,4)NSIM
4     FORMAT('1',T11,'CASE NUMBER',T25,I2///T11,'ALL RANKS -
     1 NO SIGNIFICANT DIFFERENCE BETWEEN WORKER CHARACTERIST
     2ICS')
      WRITE(6,22)XR
22    FORMAT(//T11,'FRIEDMAN STATISTIC EQUALS',T36,F10.4)
      GO TO 369
8002  WRITE(6,5)
5     FORMAT(//T11,'LOWER RANKS - NO SIGNIFICANT DIFFERENCE
     1BETWEEN WORKER CHARACTERISTICS')
      WRITE(6,22)XR
      GO TO 369
8003  WRITE(6,6)
6     FORMAT(//T11,'JUNIOR NCOS - NO SIGNIFICANT DIFFERENCE
     1BETWEEN WORKER CHARACTERISTICS')
      WRITE(6,22)XR
      GO TO 369
8004  WRITE(6,7)
7     FORMAT(//T11,'STAFF NCOS - NO SIGNIFICANT DIFFERENCE B
     1ETWEEN WORKER CHARACTERISTICS')
      WRITE(6,22)XR
      GO TO 369
8005  WRITE(6,8)
8     FORMAT(//T11,'SENIOR STAFF NCOS - NO SIGNIFICANT DIFFE
     1RENCE BETWEEN WORKER CHARACTERISTICS')
      WRITE(6,22)XR
      GO TO 9999

WRITE OUTPUT IF SIGNIFICANT DIFFERENCES EXIST

8500  WRITE(6,660)NSIM,NOMER
660   FORMAT('1',T11,'CASE NUMBER',T25,I2,T31,'CYCLE NUMBER'
     1,T46,I2///T11,'SIGNIFICANCE GROUPS OF CHARACTERISTICS'
     2///T11,'WRKR CHARAC      MEAN RATING')
      LLGP=1
      DO 665 I=1,57
      NML=I+1
      IF(ORDMN(I).EQ.0)GO TO 665
      WRITE(6,661)LLGP
661   FORMAT(//T2,'GROUP',T8,I2)
      LLGP=LLGP+1
      WRITE(6,662)ORDMN(I),XBAR(ORDMN(I))
662   FORMAT(//T17,I2,T27,F10.4)
      DO 666 J=NML,58
      IF(NGRP(ORDMN(I),ORDMN(J)).EQ.1)GO TO 666
      WRITE(6,663)ORDMN(J),XBAR(ORDMN(J))
663   FORMAT(/T17,I2,T27,F10.4)
      DO 667 K=1,58
667   NGRP(ORDMN(K),ORDMN(J))=1
      ORDMN(J)=0
666   CONTINUE
      ORDMN(I)=0
665   CONTINUE
      WRITE(6,22)XR
      IF(NOMER.LT.5)GO TO 369
      GO TO 9999
193   STOP
      END
```

LIST OF REFERENCES

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